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# The Birth and Death of the Universe

Jonah Miller

Los Alamos National Laboratory

PEEC Planetarium Live Streamed Talk  
December 3, 2021

# Change the Channel...

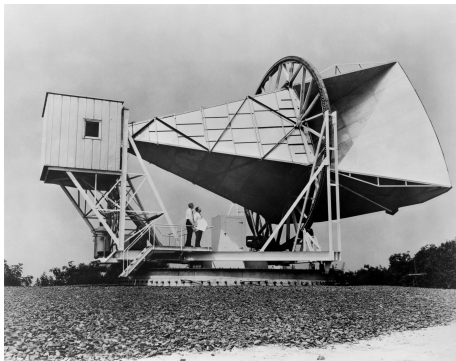
- ...And listen to the birth pangs of the universe!



Credit: Getty Images, Jeffrey Coolidge

# Project Echo, or The World's First TV Static

- **Goal:** Use those big horn antennae (left) to reflect radio signals off of those giant metal spheres (right), which were launched into space

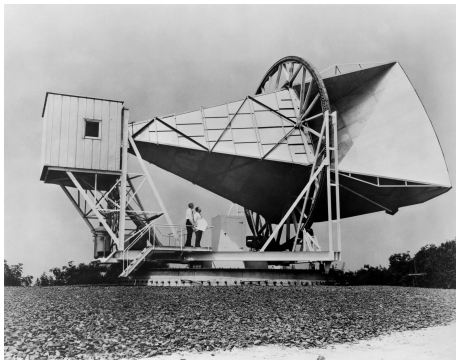


Credit: NASA



# Pigeon Poop or the Big Bang?

- Horn Antenna



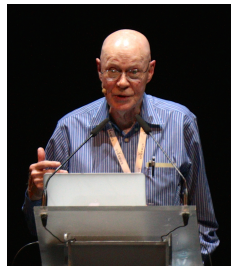
Credit: NASA

- Arno Penzias



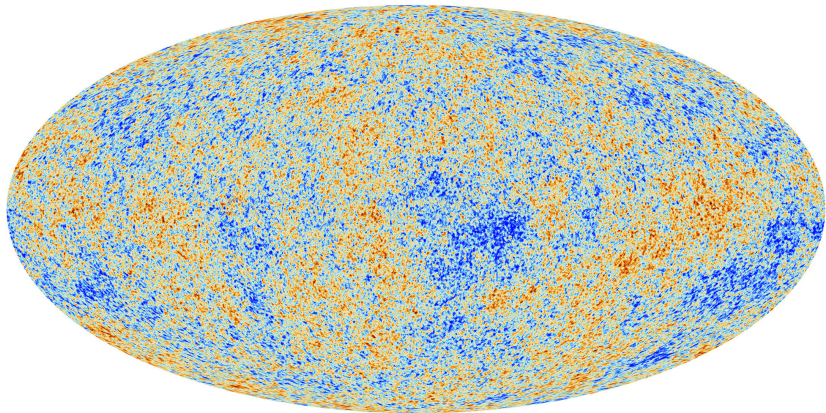
Credit: Kartik J

- Robert Wilson



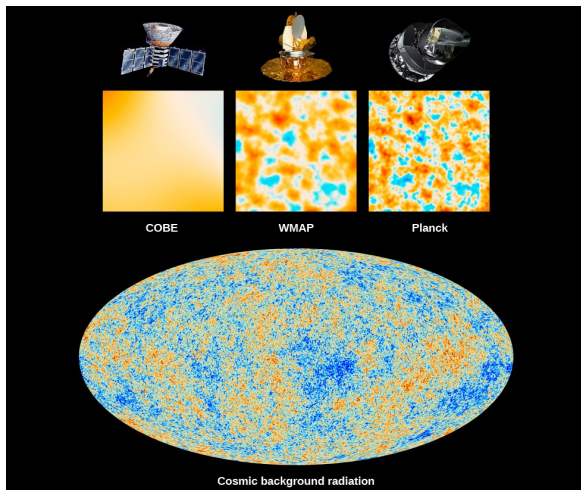
Credit: V. R. Ruiz

# The Cosmic Microwave Background (CMB)



Credit: ESA/Planck

# How Far We've Come



Credit: NASA

# A Rogues Gallery of Cosmologists

- Ralph Alpher



- Robert Dicke



- Jim Peebles



- Yakov Zeldovitch



# But let's focus on these three...

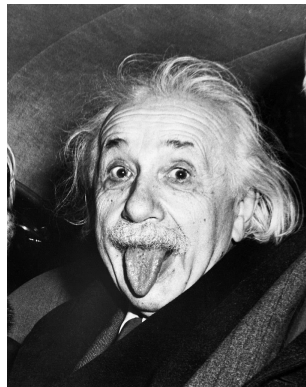
- Edwin Hubble (The Astronomer)



- Georges Lemaitre (The Priest)



- Albert Einstein (The Genius)





# The Priest and Einstein's Greatest Blunder



Credit: NASA/HST

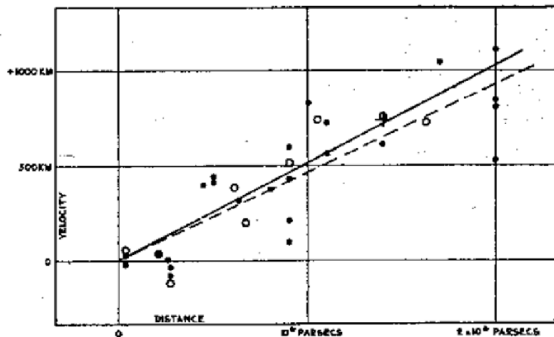
- Gravity comes from the curvature of spacetime.
- Einstein's theory doesn't permit static solutions. The universe *must* evolve!
- Lemaitre realized this—and showed his results to Einstein.
- Einstein modified his theory to fix it!

# Hubble and the Expanding Universe



Credit: Mt. Wilson Observatory Archive

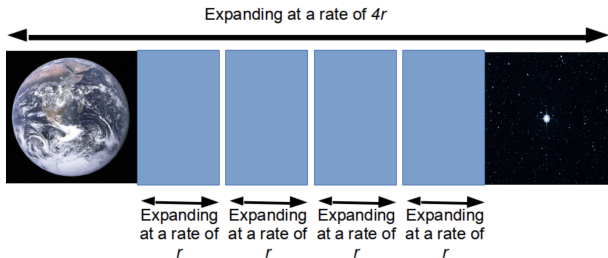
Velocity-Distance Relation among Extra-Galactic Nebulae.



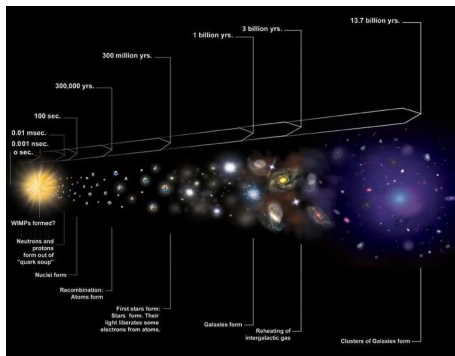
# Hubble and the Expanding Universe



Credit: Mt. Wilson Observatory Archive



# Let's Rewind



Credit: NASA

- If things are moving apart now, they must have been closer together in the past
- Denser means hotter
- 13.6 billion years ago, they would be so close together, so hot and dense, that not even subatomic particles could form
- That's the big bang!
- The Cosmic Microwave Background is leftover radiation from that early time!

# Misconceptions about the Big Bang

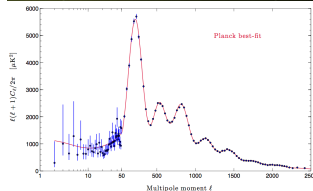
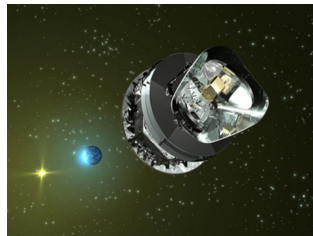
- The Big Bang was not an explosion!
- There is no center of the universe. The Big Bang was not a point.
- The universe can be expanding *and* infinite.
- The universe is not expanding into anything.

# So what's before the Big Bang?

- Nobody knows!
- Possibilities:
  - Nothing... “Before” has no meaning.
  - Big Bounce/Cyclic universe
  - Inflation
  - Eternal inflation/Many universes

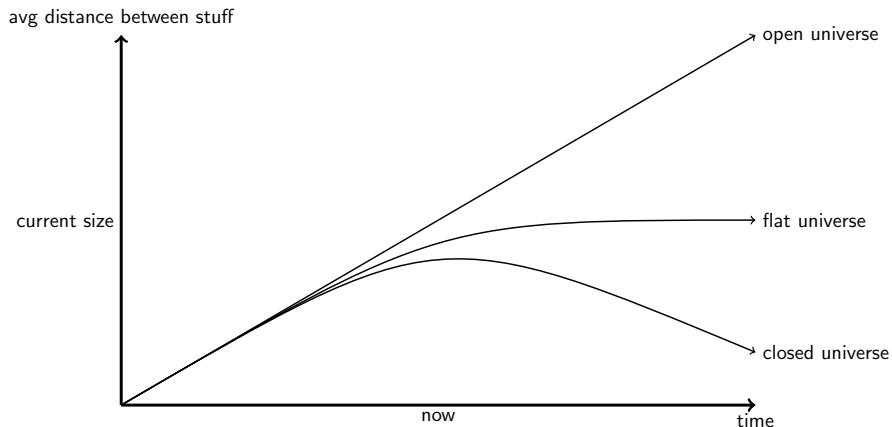
# So Much Amazing Science

- Precision cosmology with Planck et al.
  - CMB Power Spectrum
  - Primordial gravitational waves
  - Dark matter and dark energy
  - The shape of the universe
- *Almost problems* with the Big Bang:
  - Flatness
  - Horizon
- Possible solutions:
  - Cosmic inflation?
  - Many universes?



Credit: ESA/Planck

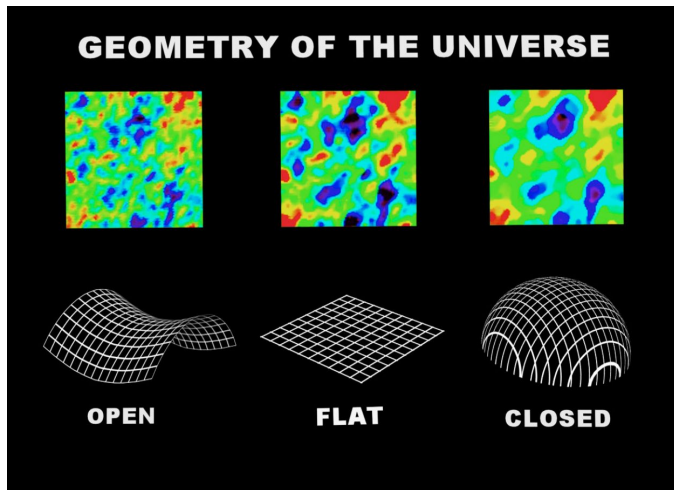
# We talked about the beginning... What about the end?





# We talked about the beginning... What about the end?

- Shape of the universe from the CMB



Credit: NASA

# We talked about the beginning... What about the end?



Credit: Mt. Wilson Observatory Archive

Velocity-Distance Relation among Extra-Galactic Nebulae.

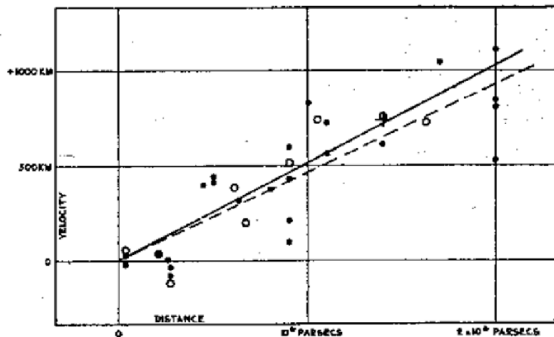


FIGURE 1

# We talked about the beginning... What about the end?



Credit: NASA

Velocity-Distance Relation among Extra-Galactic Nebulae.

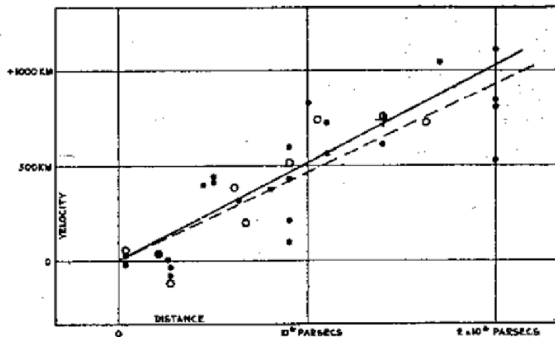
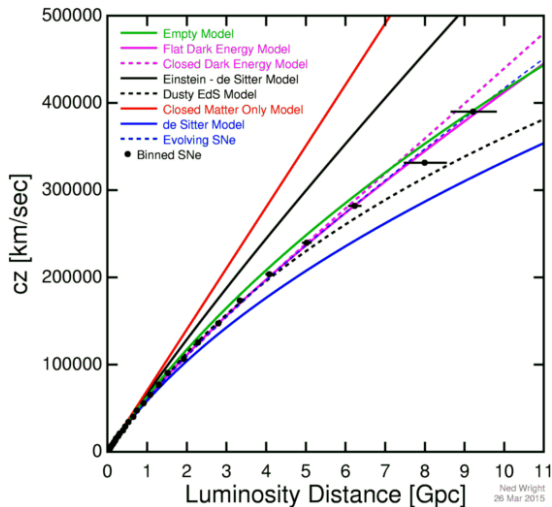


FIGURE 1

# We talked about the beginning... What about the end?



Credit: NASA

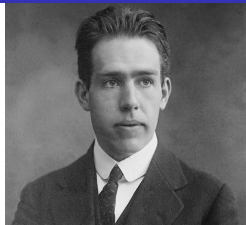


Credit: Betoule et al. (2014)

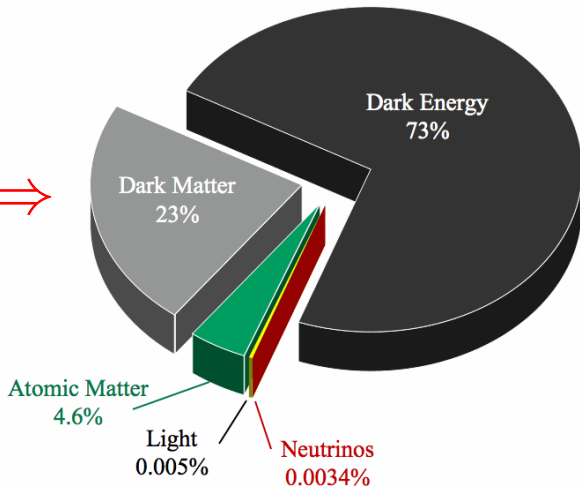
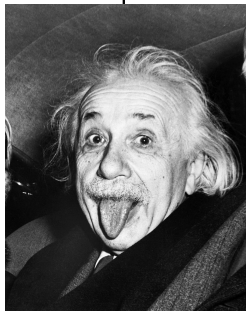
# The Universe is Accelerating... Why?

- We don't know!
- We just call it dark energy

# The Worst Prediction in the History of Physics

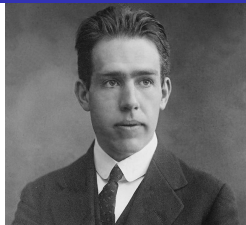


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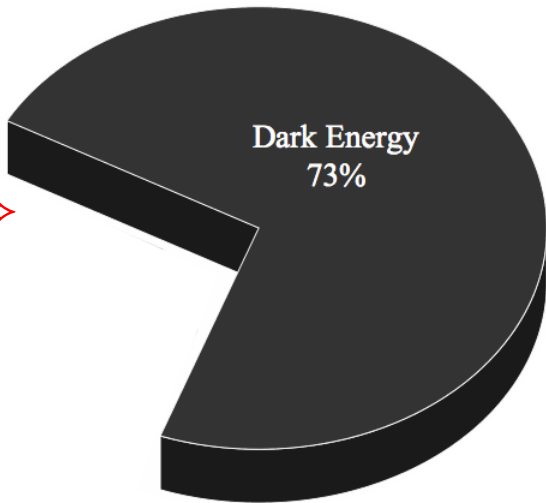
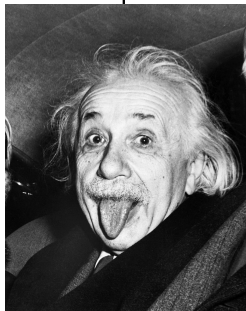


source: wikipedia commons

# The Worst Prediction in the History of Physics



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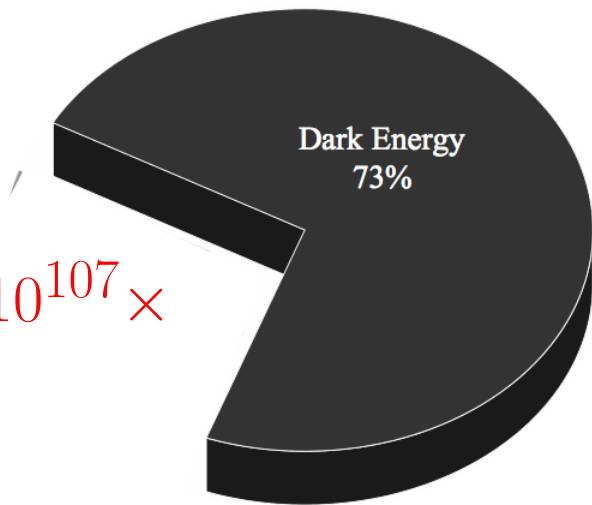


source: wikipedia commons

# The Worst Prediction in the History of Physics



$10^{107} \times$



source: wikipedia commons



# The Worst Prediction in the History of Physics



source: [kissofdead06](#) on DeviantArt

# The Worst Prediction in the History of Physics



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Universe

Dec 3, 2021

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# The Worst Prediction in the History of Physics



**Vacuum Catastrophe!**



source: [kisssofdead06 on DeviantArt](#)

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# The Worst Prediction in the History of Physics



source: Metallica

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Universe

Dec 3, 2021

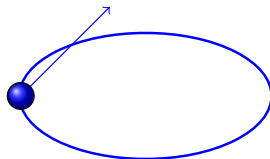
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# Cosmological Horizons and the Edge of the Universe

Us, Today



Present



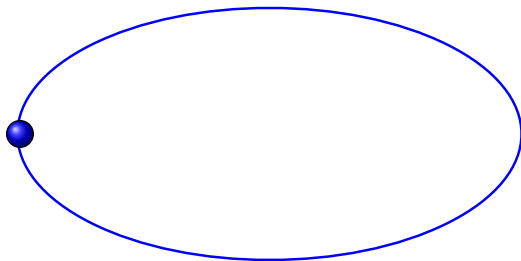
Past

# Cosmological Horizons and the Edge of the Universe

Us, Today

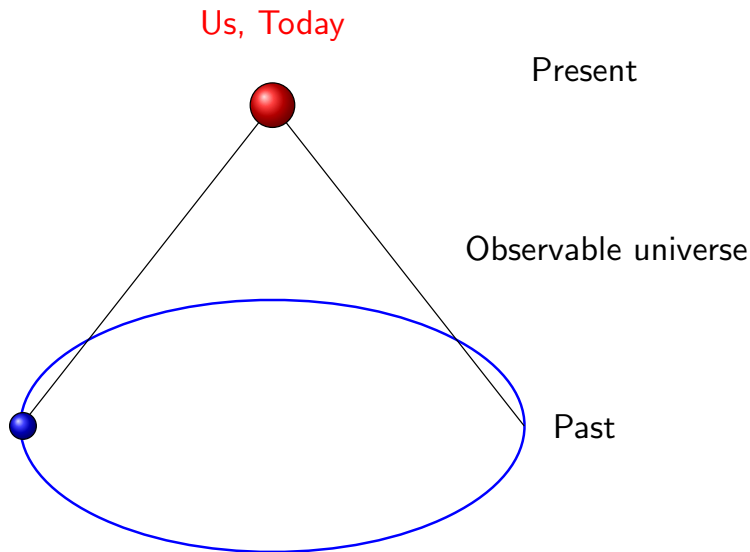


Present



Past

# Cosmological Horizons and the Edge of the Universe



# In The End...

- ...Long after the sun has died and the Earth is gone...
- ...The Universe will eventually expand so quickly that light from a distant star can't reach us
- Slowly, each of the stars in the night sky will blink out, as they get too far away
- When the night sky is totally dark, eventually the expansion of the universe will rip apart atoms and molecules
- And everything, absolutely everything, will be diluted to nothing.